by J. A. Xu, H.-K. Mao, and P. M. Bell at the Geophysical Laboratory of the Carnegie Institution of Washington. This pressure range encompasses the entire earth from surface to core (central core pressures are estimated to be 3.5 Mbar), as well as pressures equivalent to the upper mantles of the giant planets. This enhanced ability to synthesize mineral phases, measure their properties, and observe their behavior will result in improved evaluation of models of earth and planetary interiors.

The high-pressure experiments to 5.5 Mbar involved implementation of new design concepts for the diamond anvil apparatus. In a previous experiment the maximum pressure achieved was approximately 2.8 Mbar, but the pressure calibration had to be done indirectly from load calculations. The shift of the fluorescent line of ruby crystals placed in the sample, which is normally employed as an internal pressure standard, could not be used in the earlier experiment because of strong interference from diamond anvil fluorescence at pressures above 2.7 Mbar. In the new experiments the overlapping diamond emission was found to disappear at pressures above 3 Mbar, and the ruby pressure calibration scale could be employed once again. The apparatus is suitable for experiments with silicates, metals, and solidified gases. These new methods will facilitate the study of mineral physics under experimental conditions that duplicate the natural conditions of the earth's interior.

Editor's Note: Brief summaries of significant new experimental or theoretical results of interest to the mineral physics community are welcome. Please send information to the Mineral Physics News Editor.

Meetings

International Mineralogical Association Meeting

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The 14th General Meeting of the International Mineralogical Association (IMA) will be held in Stanford, Calif., July 13–18, 1986. Several symposia at this meeting will be of special interest to the mineral physics community. These sessions include

- Mineralogical Applications of Synchrotron Radiation
- Structural Classification of Minerals
- Thermodynamics and Kinetics of Mineral Reactions
- Ordering, Transformations, and Modulated Structures in Phyllosilicates
- Structural and Magnetic Phase Transitions of Minerals
- Physics and Chemistry of Mantle Minerals
- Applications of solid-state Nuclear Magnetic Resonanace (NMR) to Minerals
- Defect Structures in Minerals
- Electron Microscopy of the Kinetics of Mineral Transformations

In addition, symposia will focus on specific mineral groups, petrology of igneous rocks, optical microscopy, industrial mineralogy, and other topics. Plenary lectures by Ekhard Salje on the application of order parameter theory to the thermodynamic properties of phase transitions and by Ian Jackson on the elasticity of mantle minerals will also be of special interest to mineral physicists.

For additional information on the IMA meeting, write IMA 1986, Department of Geology, Stanford University, Stanford, CA 94305.

Quantum Theory and Experiment Applications

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On July 21–26, 1986, a conference on quantum theory and experiments applied to solids will be held in College Park, Md. This conference will bring together theoreticians and experimentalists from the fields of mineralogy, geophysics, solid-state physics, and chemistry. Its objectives are

- to examine the capability of various theoretical methods, including solid-state band theory, ionic model simulation, molecular cluster theory, and qualitative MO band theory for explaining the properties of solids,
- to present recent experimental data on solids at extreme pressure and temperature, defect solids, glasses and surfaces to which the above methods may be applied, and
- to focus on some particular topics of current and future interest to mineralogists and other solid-state scientists.

For more information, contact the organizers: Jack Tossell (Department of Chemistry, University of Maryland, College Park, MD 20742) or G. V. Gibbs (Department of Geological Sciences, Virginia Polytechnic Institution and State University, Blacksburg, VA 24061).

Lithosphere and Asthenosphere

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An International Workshop on Anisotropy and Inhomogeneity of the Lithosphere and Asthenosphere will be held on September 8–13, 1986, at the Castle of Bechyně, Czechoslovakia. The conference is being organized by the Geophysical Institute of the Czechoslovakia Academy of Sciences and the Institute of Geophysics of Charles University in Prague.

The first part of the workshop will focus on three-dimensional seismic mapping of the lithosphere and asthenosphere and on the generation of propagation of seismic waves within anisotropic and inhomogeneous media. The rest of the meeting will be devoted to considering experimental data and their application to the interpretation and implications of the velocity variations in the mantle. Mineral physics has much to contribute to this latter discussion, and anyone interested in participating in the workshop is encouraged to contact V. Babuška, Geophysical Institute, Czechoslovakia Academy of Sciences, 141 31 Prague 4 – Spořilov, Czechoslovakia; Telex 121330 or R. C. Liebermann, Department of Earth and Space Sciences, State University of New York, Stony Brook, NY 11794.

High-Pressure Research Applications Seminar

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The United States–Japan seminar on "High-Pressure Research Applications in

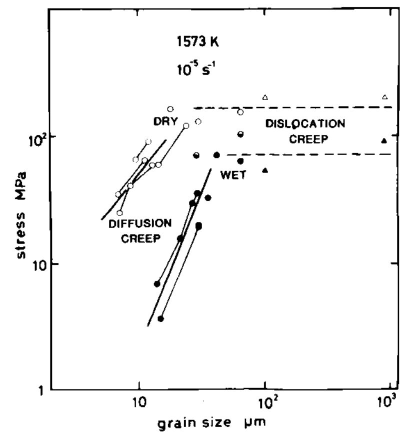

Fig. 4. Experimental determination of the boundary between the regimes in which diffusion and dislocation creep dominate the deformation of synthetic olivine aggregates. In the diffusion creep regime (small grain size, low stress), the flow stress is sensitive to grain size, and the flow is approximately Newtonian. In the dislocation creep regime (large grain size, high stress), the flow stress is insensitive to grain size, and the strain rate varies as the third or fourth power of stress. The presence of water lowers the flow stress in both regimes, as may be seen by comparing the stress–grain size curves for dry and wet specimens (Karato, Paterson and Fitz Gerald).

Geophysics and Geochemistry" was held in Honolulu, Hawaii, January 13–16, 1986, under the auspices of the National Science Foundation (NSF) and the Japan Society for the Promotion of Science (JSPS). The seminar, the third in a series, was cocovened by Murli H. Manghnani (University of Hawaii, Honolulu) and Syun-iti Akimoto (University of Tokyo). Coming together for this symposium were 25 researchers from Japan, 22 from the United States, and four others, from Australia, the People's Republic of China, the Netherlands, and the Federal Republic of Germany. Of the 52 papers presented, 38 were presented orally at seven scientific sessions, and the rest were displayed at a poster session.

The scientific sessions covered a variety of state-of-art experimental techniques and theoretical topics:

- High-Pressure Techniques and Melting Experiments
- Shock Wave Experiments
- Synthesis, Phase Equilibria, and Thermodynamic Properties of Mantle Phases
- Spectroscopy at High Pressure
- Application of Synchrotron Radiation
- Lattice Dynamic Studies
- High-Pressure Research Applications in Geophysics and Geochemistry (poster session)
- Geophysical and Geochemical Constraints

In the opening lecture, Akimoto reviewed the past, present, and future of high-pressure research in geophysics, emphasizing the progress made over the past 25 yr in his laboratory at the University of Tokyo's Institute of Solid State Physics. The highlights of the recently developed high-pressure techniques were the melting and phasing transition studies that used laser- and resistance-heated diamond anvil cells (DAC). In the former case, tablish the age relationships of floodplain surfaces along the Little Missouri River in western North Dakota. He documented that a higher floodplain surface was not a postglacial terrace that formed from isostatic rebound following retreat of the last ice sheet, as was believed formerly. Cottonwood trees on the lower surface were no older than 15 yr; cottonwood trees on the upper surface were no younger than 35 yr. Using this botanic evidence as his guide, Everitt documented that a large flood in 1947 had caused extensive channel widening, destruction of all cottonwood trees on the channel floor, and formation of a pronounced erosional scarp that was 1.5–3 m high. Cottonwood trees were the clue to the history of the valley sediments and landforms produced by the flood in 1947.

Following the disastrous Christmas flooding in northern California in December 1964, J. H. Stewart and V. C. LaMarche investigated the valley of Coffee Creek, Calif., which was severely modified by the flooding [*Stewart and LaMarche*, 1967]. They determined that many trees toppled in the flood were from 200 to more than 400 yr old. These trees had survived all previous floods in at least the last 200 yr. Previously undisturbed alluvial fan deposits along the valley sides were extensively eroded. These sediments were as old as 1700 ^{14}C yr. Bouldery natural levee deposits were a prominent depositional feature produced by the flood. Older levee deposits were widespread on the valley bottom of Coffee Creek, and the highest old deposits were as much as 0.6 m above the high-water lines of the 1964 flood. This indicates that floods larger than the flood of 1964 had occurred in the valley, if it can be assumed that there had not been extensive valley degradation.

In mid-June 1965, intense rains caused extraordinary flooding in the South Platte River basin in eastern Colorado. Bijou Creek, a tributary to the South Platte River, was severely flooded, and the extensive sand deposits from the flood were investigated in detail by *McKee et al.* [1967]. H. F. Matthai of the U.S. Geological Survey supplied hydraulic and scour data for the project and suggested additional locations that had extensive flood deposits for investigation. McKee et al. documented that floodplain sand deposits were hundreds of meters wide and as much as 3.7 m thick. Thinly bedded horizontal strata, formed in the upper flow regime, constituted 90–95% of all deposits. Extensive horizontal bedding, in association with climbing ripple laminations and convolute structures, was determined to be diagnostic of blanket sand deposits formed by flash floods.

H. E. Malde investigated the catastrophic flood caused by the overflow and lowering of Pleistocene Lake Bonneville at Red Rocks Pass near Preston, Idaho [*Malde*, 1968], about 14,000 yr ago [*Scott et al.*, 1980]. C. T. Jenkins (U.S. Geological Survey) computed a flood peak of 0.42×10^6 m^3 s^{-1} at a canyon neck south of Boise, Idaho, for Malde, by assuming that the canyon acted as a gigantic streamflow measuring device (venturi flume) and that the flood was at critical depth [*Malde*, 1968, p. 12]. Flood discharges also were estimated at nine locations along the Snake River canyon in southern Idaho by using Manning's equation and $n = 0.03$.

In 1968, P. W. Birkeland estimated the mean velocity and tractive force necessary to transport glacial outwash boulders in the Truckee River in California and Nevada [*Birkeland*, 1968]. While this was not the first attempt to reconstruct hydraulic parameters from boulder sizes, it was one of the first reports solely devoted to such paleohydraulic reconstructions. Paleoflood velocities and tractive forces were estimated by the Manning equation to be about 9.1 m s^{-1} and 958–1437 N m^2, respectively, for a flood transporting $12.2 \times 6.1 \times 3.0$–m boulders in a flow 12.2–24.4 m deep at a slope of 0.007. Values of n were chosen to be 0.06–0.08.

This history of paleoflood hydrology ends at 1970 because this date marks a threshold in paleoflood interest and methodology. Beginning with the flooding caused by Hurricane Camille in 1969 and ending with the Buffalo Creek, W.Va., Rapid City, S.D, and Hurricane Agnes floods in 1972, in which nearly 500 lives were lost, major federal laws such as the Flood Disaster Prevention Act (Public Law 93–234) focused renewed multidisciplinary efforts in flood studies, including paleoflood hydrology. Since 1970 there has been an exponential increase in the types and number of paleoflood investigations. Because the primary purpose of this report is historical background, 1970 was a logical point at which to end it. For more information about post-1970 ways to estimate paleoflood magnitude, the papers by *Kochel and Baker* [1982], *Foley et al.* [1984], and *Williams* [1984] are recommended. A summary of contemporary approaches to estimate paleoflood frequency can be found in the work of *Costa* [1978].

Conclusions

The development of paleoflood hydrology has been an excellent example of the interdisciplinary cooperation of several specialized sciences. Hydrologists and engineers provided the preliminary computations, which were based on energy equations from open channel hydraulics or sediment transport, that were used by geologists in attempting to reconstruct flow characteristics of large Pleistocene floods. Geomorphic, botanic, and sedimentologic evidence was then recognized as helpful for extending flood frequency estimates beyond the period of record, as well as for estimating the magnitude of past large flows. Paleoflood hydrology has not yet been developed to its greatest potential, but it will become more and more of an integral part of water resources investigations [*Greis*, 1983]. Therefore the origins of this important subject need to be documented as well as possible.

Acknowledgments

I would like to thank R. F. Hadley, V. R. Schneider, J. M. Stewart, C. R. Hupp, R. C. Kochel, D. E. Hillier, V. R. Baker, and W. H. Kirby for their helpful reviews of the manuscript.

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Thus exciting opportunities in high-pressure mineral physics lie ahead.

This report was contributed by Murli H. Manghnani, *University of Hawaii, Honolulu;* Syun-iti Akimoto, *University of Tokyo;* Thomas J. Ahrens, *California Institute of Technology, Pasadena, Calif.;* Yasuhiko Syono, *Tohoku University, Sendai, Japan;* Raymond Jeanloz, *University of California, Berkeley; and* Takehiko Yagi, *University of Tokyo.*

Chairman's Corner

Mineral Growth

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Mineral physics, like its sister disciplines geochemistry, petrology, and crystallography, is a derivative of the old discipline of mineralogy. At the turn of the century, mineralogy was one of the strongest pillars in the European University, but it was weakened by the loss of these branches, which declared their independence as they matured. One of the most important roots of solid state physics also branched off from 19th-century mineralogy.

Yet solid state physics, bound securely in the Physics Department, developed in a way that took it further and further from the interests of geological sciences. In the late 1960's, it became evident that a gap existed in laboratory and theoretical geophysics that was not filled by the then-existing disciplines of solid state physics or mineralogy. To fill this gap, it was required that the principles of solid state physics be applied to minerals of especial interest to geophysics.

The gap was wide but not vacant. Francis Birch of Harvard published several classic papers in the early 1950's and 1960's that demonstrated the power of using solid state principles to attack problems of the solid earth interior. Birch became the role model for a later generation who called themselves mineral physicists.

The path pioneered by Birch was settled by scientists who by and large stayed within the geophysical community and published especially in the AGU journals. Logically, they could have published in physics journals or in mineralogy journals. That they chose to publish mostly in geophysics journals may have been because they were united with other geophysicists in coordinated attempts to understand properties and processes of the earth's interior.

Even within the American Geophysical Union, those following Birch's path found themselves to be slightly out of step with others in the traditional disciplines of geophysics. The focus on physical properties of rock-forming minerals did not harmonize easily with a focus on geophysical phenomena (e.g., earthquakes, volcanos, etc.). The extrapolation from atomic properties to global properties was made along a different trajectory than the one used by seismologists, geodesists, and volcanologists.

For a long while, the followers of the Birch tradition had no disciplinary name, and they were identified in national and international programs under such appellations as "physical properties of earth's interior" or "physical properties of geologic materials." It became important, therefore, to find a name that could capture the spirit and flavor of scientists who worked on physical problems of rock-forming minerals. At the occasion of their organization within AGU, the designation "mineral physics" was adopted, although with some reluctance because it did not include some reference to chemistry. Among the members of the Mineral Physics Committee, the word "chemistry" is always implied, just as work in geochemistry is always implied in the title "American Geophysical Union."

In Birch's classic paper "Elasticity and Constitution of the Earth's Interior" (*Journal of Geophysical Research*, vol. 57, pp. 227–286, 1952), he presented several avenues of analysis:

- the calculation of P ( ) by means of an equation of state;
- the determination of thermal properties from seismic properties by the use of classical solid state equations;
- the determination of nonhomogeneous regions from seismic data and the identification of some of those inhomogeneities as high-pressure phase changes arising in olivine and pyroxene, "possibly close-packed oxides of magnesium, silicon, and iron, similar in structure to corundum, or rutile, or spinel"; and
- the analysis of seismic data coupled with solid state equations to support the hypothesis of a predominantly iron core.

Shortly after publishing this historic pape[r] Birch published other important papers: on[e] showed the significance of shock wave measurements to bear on the question of core constitution, and in another, he introduced the idea that physical properties of rock-forming minerals are controlled primarily b[y] density. In his 1952 paper, he anticipated th[e] direction of present theory on equations of state by his statement that "as yet, there are no complete quantum-mechanical studies fo[r] materials likely to be important in the interi[or] of the earth," clearly implying the need for this work.

These research directions formulated or anticipated by Birch still guide much of the work of mineral physicists. This is seen by th[e] contents of the recent report [by William A. Bassett of Cornell University, Ithaca, N.Y.], called "Mineral Physics: Atomic to Global," [a] summary of which will be published soon in *Eos*. The Mineral Physics Committee of the American Geophysical Union issued their Lake Arrowhead study, which described future research opportunities for the late 1980['s] and 1990's. In this report a number of fundamental questions about the nature and dynamics of the earth's interior were described, and the contribution that mineral physics can make to the solution of these questions were listed as work in the followin[g] areas:

- The equation of state;
- Elastic and anelastic properties;
- High-pressure/high-temperature crystallography;
- Phase transformation;
- The nature and movement of melts;
- Theoretical modeling;
- Transport properties and crystal defect[s]
- Inelastic deformation;
- Mineral magnetism;
- Behavior of hydrogen and helium at hig[h] pressure and temperature;
- The state of iron in the interiors of terrestrial planets;
- Partitioning of lithophilic elements in th[e] lower mantle;
- Core-mantle boundary

Since about half of these topics were introduced by Birch, a claim can be made that mineral physics as a discipline has a continuous record of 30 years, although a formal recognition is only 3 years old.

Orson L. Anderso[n]
Chairman, AGU Mineral Physics Committ[ee]